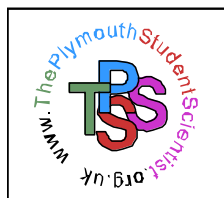


The Plymouth Student Scientist, 2008, 1, (1), 345-364



A Review of Combined Diet and Exercise Weight Loss Interventions in Obese and Overweight Adolescents

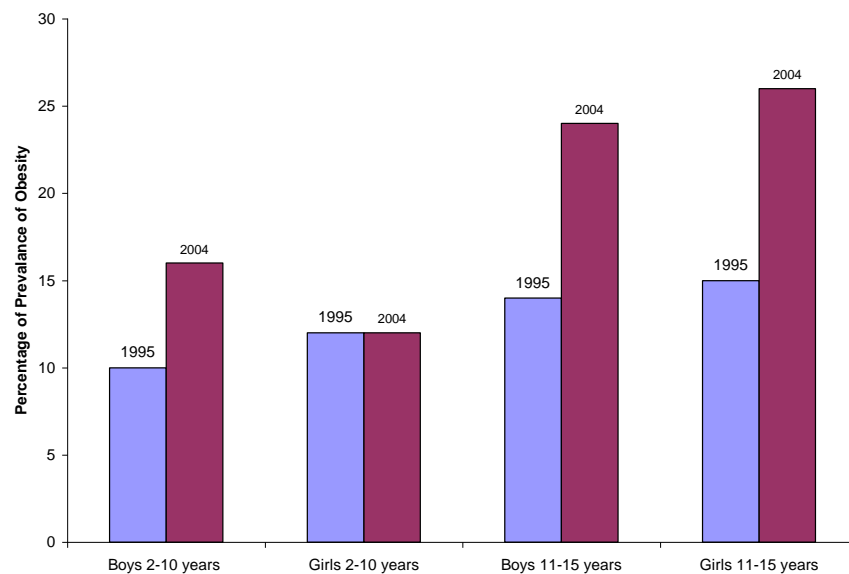
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Introduction

Obesity is on the increase amongst children and adolescents (figure 1); statistics from The Health Survey for England (2004) state that from 1995 to 2004, obesity in boys increased from 14% to 24% and 15% to 26% for girls (figure 1). Approximately, one in four 11 to 15 year olds was classified as obese (The Health Survey for England 2004). However, differing measurements of body composition exist (Table 1) and cut-off points for overweight and obesity vary between studies (Shepard 2005); creating difficulties in the reliability of statistical data.

Figure 1. Prevalence of obesity in children and adolescents.



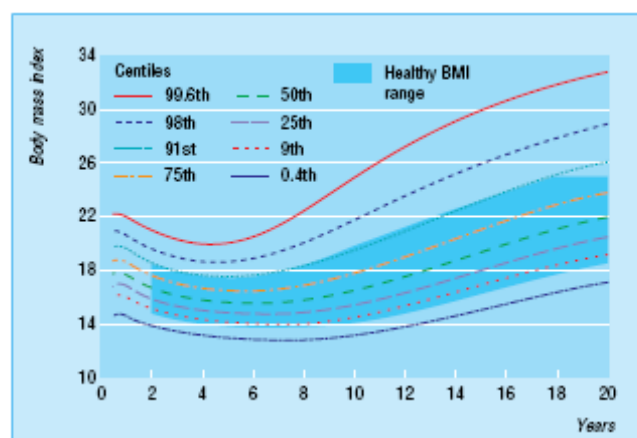
Source adapted from: The Health Survey for England (2004). *Updating of trend tables to include childhood obesity data*. The Stationary Office, London, UK.

Table 1. Body Composition Measurements

<u>Method</u>	<u>Brief Description</u>
Dual-energy X-ray absorptiometry (DXA)	Separates body weight into lean tissue, fat tissue and bone, based on the differential attenuation by tissues, of two levels of x-rays (Heyward 2001).
Bioelectrical Impedance Analysis (BIA)	Body density & body fat percentage is measured by the body's resistance to an electrical current (ACE 1997).
Hydrostatic Weighing	Under Water Weighing – “Body density is calculated from the relationship of normal body weight to underwater weight. Body-fat percentage is calculated from body density” (ACE 1997, p183).
Skinfold Measurements	Estimation of body fat based on the principle that 50% percent of total body fat lies under the skin (ACE, 1997). Measures skinfold site using callipers.
Magnetic Resonance Imaging (MRI)	Magnetic and radio waves affect the body's atoms. Produces a picture of the tissues in the body.
BOD POD	Measurement of body volume & body density by air displacement plethysmography (Heyward 2001).
Waist-to-Hip Ratio	An estimate of body-fat distribution. Divide waist measurement by hip measurement.
Body Mass Index (BMI)	Indicator of normal weight according to stature. Weight in kg is divided by height in metres squared.
Waist Measurement	Visceral adiposity is associated with an increased risk of metabolic disease.

The body mass index (BMI, kg/m²) is an accepted measure of adiposity (Reilly and Wilson 2006); although in children and adolescents, age, sex and growth, as well as height and weight, need to be considered (Shepard 2005). Gender specific, height and weight, BMI centile reference charts are more accurate in plotting growth in children and adolescents (figure 2) (Reilly and Wilson 2006), however, different guidelines for BMI markers of overweight/obesity exist (Table 2) (Department of Health 2006), making universal standard markers difficult. UK BMI for age charts (1990), classify overweight and obesity in children as a BMI >91st percentile and >98th percentile respectively for age and sex (Reilly and Wilson 2006).

Figure 2. Example of a BMI Centile Chart showing some body mass index curves



Source: Reilly, J.J. and Wilson, D. (2006). Childhood Obesity. *British Medical Journal (BMJ)*, 333, 1207-1210.

Table 2. Showing cut-off markers for overweight and obesity

Guidelines	Overweight	Obesity
National Health and Medical Research Council (NHMRC), (2003)	> 85 th percentile	> 95 th percentile
Scottish Intercollegiate Guidelines Network (SIGN, 2003)	> 91 st percentile	> 98 th percentile
Department of Health	> 91 st percentile	> 98 th percentile

Source adapted from: Department of Health (2006). *Measurement and assessment of overweight and obesity - children*
www.fph.org.uk/policy_communication/downloads/publications/toolkits/obesity/Tool_05.pdf

Sedentary lifestyles and eating habits have been named as contributing factors in the growing childhood obesity epidemic (National Audit Office (NAO) 2001). Physical activity levels through childhood to adolescence decrease in both sexes (Armstrong and Welsman 2000). An increase in television watching (> 5 hours a day) has been associated with a 4.6 greater chance of being overweight (Gortmaker et al. 1996). An increase in consumption of fast foods, sweetened drinks and sugary foods in children and adolescents is also apparent; on average, children in the UK are eating over the recommended levels of sugars, fats and salt per day (British Medical Association (BMA) 1999).

Obesity in adults is also increasing; with one in four adults being classified as obese (The Health Survey for England 2004). This leads to a major government concern in relation to reducing morbidity and mortality of obesity related diseases. Research has indicated that obesity in childhood continues to track into adulthood (Dietz and Gortmaker 2001).

Health risk factors known as metabolic syndrome (high blood pressure, elevated triglycerides, low HDL, glucose intolerance, elevated insulin levels and excessive body fat) increase the likelihood of developing early type II diabetes and coronary heart disease (Harrell 2003). Table 3 outlines the

consequences of childhood obesity. In a study of 3,203 children in rural schools, initial baseline results showed that 58% of children between the ages of 8 and 17 had at least one metabolic syndrome risk factor and multiple risk factors were highest (16%) in children between the ages of 10 and 13 years (Harrell 2003). Prevention and treatment of childhood and adolescent obesity, is at the forefront of government concerns (Centre for Reviews and Dissemination (CRD) 1997).

Table 3. Conditions associated with childhood and adolescent obesity

Consequences of paediatric obesity
Short term (for the child or adolescent)
Psychological ill health
Cardiovascular risk factors
Asthma
Chronic inflammation
Diabetes (type 1 and 2)
Orthopaedic abnormalities
Liver disease
Long term (for the adult who was obese as a child or adolescent)
Persistence of obesity
Adverse socioeconomic outcomes, particularly in women
Cardiovascular risk factors, diabetes, cancers, depression, arthritis
Premature mortality

Source adapted from: Reilly, J.J. and Wilson, D. (2006). Childhood Obesity. *British Medical Journal (BMJ)*, 333, 1207-1210.

Research on interventions to tackle childhood and adolescent obesity is limited (Reilly and Wilson 2006). Contrasting results are apparent; Wardle (1996) stated that interventions focusing on either diet or physical activity have been less successful than multi-component programmes. Hill et al. (1987) concluded that exercise coupled with dietary restriction is more efficient in losing body fat. However, a recent review by Summerbell et al.

(2005) highlighted that studies focusing on either diet or physical activity showed a positive impact on BMI compared to combination interventions of diet and physical activity.

This report reviews combination intervention studies for overweight and obese adolescents; with the main focus being on exercise and nutrition. Firstly, the report looks at the method of research and discussion of results, including study environments, sample selection, common obesity markers and intervention methods. Finally, an analysis of study results and a discussion and summary of the main points found.

Research Method

Intervention studies were identified using search engine databases, Paediatrics Journals and cross-matching references of selected reviews. Thirty-seven studies were identified. Selection criteria were initially based on:

- Randomised control trials
- Overweight and obese adolescents' ≥ 11 years of age
- Minimum combination of diet and exercise intervention to reduce body mass

Only six randomised control studies were identified (Table 4) and only three explained the method of randomisation. "Randomised controlled studies provide the most reliable evidence for the effectiveness of interventions" (CRD 1997, p5). In order to aid reliability of the review, non-randomised and non-control group intervention studies were assessed.

Results

Twelve published studies were identified, six randomised control studies, three with a comparison or control group and three with no comparison/control group (Table 4). Only two studies were over a 12-month duration and only three studies initiated a follow-up (Table 5).

Environment

Ten (83%) out of the twelve studies were conducted in the USA. This may raise the question of validity of results when being transferred to the UK population; the difference in the cut-off points for overweight/obesity in the USA compared to the UK, may interpret a different reflective result in population comparison studies. Cultural differences in beliefs, attitudes and education towards the interventions, may also affect the long term adherence and therefore outcome of studies.

Five studies were school-based, four were residential summer camps, one was conducted at an institute and two studies required weekly meetings/exercise sessions (Table 5). Sample recruitment was through target schools or advertisements in local newspapers. Schools provide the easiest, most cost effective method of subject recruitment (Gortmaker et al. 1999). Four out of the five studies used more than one school for sample selection, although only one study used more than one community. The use of single schools in studies may limit analysis of different social and economic ranges and may question the generalisation of study results. Only one residential study (Gately et al. 2005) (Tables 4 & 5) used a comparison group. Control/comparison groups are important in establishing normal growth patterns to give a reflective population comparison. However, obese subjects can pose difficulties, due to incompatibility of samples to the normal population data (Gately et al. 2000).

All of the residential studies charged a fee for the programme (Table 5); this limits attendance to higher socio-economic status families, questioning the generalisation of the results to the average population. Research has shown that children born in to low-income families are more at risk of being overweight (BMA 1999). Externally funded places were available through health professionals, Gately and Cooke (2003) stated that the small percentage of uptake “demonstrates the lack of provision and resource for obesity treatment in the UK” (p3).

Age and Sex of Subjects

Sample sizes and selection were heterogeneous (Table 4). Zakus et al. (1981) used only 10 intervention subjects and 12 control subjects, all girls. Christakis et al. (1966) used only male subjects. Studies using small sample sizes and single gender subjects are less representative of the population, therefore questioning the generalisation of results. Maturation growth differs between sexes; girls mature approximately 2 years earlier than boys (Armstrong and Welsman 2000). Mean average age was calculated in five studies, all were at the lower adolescent age range between 12 – 14 years (Table 4). This age group is more likely to be pre-pubertal, limiting analysis of interventions through the pubertal stages. A study of 13 – 18 year olds would be more conclusive of this age group. A study by Gutin et al. (2002) found that 13 – 16 year olds were more reluctant to participate in an intervention programme than the younger age group; this may explain why most study subjects are at the lower age range (Table 4). Attrition rates of the studies are shown in Table 6.

Obesity Markers

Only two studies used more than one method to define overweight/obesity (Table 4). BMI and triceps skinfold were the most common measurements. Variations existed between the cut-off markers between studies. Cole et al. (2000) established international overweight/obesity cut off points for BMI, between the ages of 2 -18 years, however these guidelines are yet to be universally accepted. Lazarus et al. (1996) found that BMI is reasonably correct (71%), in correlation to total adiposity at the 85th percentile marker. The National Health and Research Council (2003) state that BMI classifications in children are not based on known medical or health risks. BMI does not calculate a breakdown of body composition (American Council on Exercise (ACE) 1997), which can lead to inaccuracy in the more muscular developed adolescent. Limitations in analysing visceral adiposity and therefore coronary artery disease risk factors also exist (ACE 1997). Reilly and Wilson (2006) suggested that waist circumference measurements in

children and adolescents may be an alternative to BMI, although further research is needed.

Table 4. Summary of sample size, sex, age and selection criteria of studies

Author and Year	Study Design	Sample Size	Sex	Age in Years	Study Criteria
Becque et al. (1988)	Randomised control study	36	21 Girls 15 Boys	Mean 12.8 ± 0.3	Body Weight & Triceps Skinfold > 75 th percentile for age & sex (NHNES)
Brownell, Kelman, and Stunkard (1983)	Randomised control study	42	33 Girls 9 Boys	12 - 16	20% > average weight for age, sex & height (Robinson 1972)
Carrel et al. (2005)	Randomised control study	50	24 Girls 26 Boys	Mean 12 ± 0.5	BMI > 95 th percentile for age
Christakis et al. (1966)	Randomised control study	90	90 Boys	13 - 14	Obese – determined by Baldwin Tables (1924) for height, age & sex
Gately and Cooke (2003)	No comparison or control group.	39	Not stated	11 - 17	BMI >85 percentile for age & sex
Gately et al. (2000)	No comparison or control group.	194	130 Girls 64 Boys	Mean 12.6 ± 2.5	Obese children – criteria not stated
Gately et al. (2000)	No comparison or control group	102	64 Girls 38 Boys	Mean 13.6 ± 2.4	One year re-enrolment from previous Summer Camp (Gately et al. 2000)
Gately et al. (2005)	Comparison group.	279	142 Girls 137 Boys	9 -18	BMI above cutoff values for overweight for age & sex (Cole et al. 2000)
Gortmaker et al. (1999)	Randomised control study.	1560	Girls/Boys Ratio not stated	11 - 14	BMI & Tricep Skinfolks > 85th percentile for age & sex
Gutin et al. (2002)	Randomised control study.	80	54 Girls 26 Boys	13 - 16	Triceps Skinfold > 85th percentile for sex, ethnicity & age (Must et al 1991)
Seltzer and Mayer (1970)	Non-randomised control study	350	245 Girls 105 Boys	8 - 14	Tricep Skinfold thickness (Seltzer & Mayer 1965)
Zakus et al. (1981)	Non-randomised control study.	22	22 Girls	Mean age 14	Criteria - 10% or more over ideal weight (NCHS)

Abbreviations: NHNES - National Health & Nutrition Examination Survey, BMI - Body Mass Index (kg/m²), NCHS - National Centre for Health Statistics.

Table 5. Summary of length of programme, interventions and results of studies

Author and Year	Programme	Intervention	Results
Becque et al. (1988)	20 Weeks Overnight stay	Group 1 – Control Group Group 2 – Diet & Behaviour Change Group 3 - Exercise, Diet & Behaviour Change	<u>Body Weight & BF%</u> Group 1 - ↑3.2kg BF - ↑0.7% Group 2 - ↓0.4kg BF - ↓3.5% Group 3 - ↓1.6kg BF - ↓3%
Brownell, Kelman, and Stunkard (1983)	16 Weeks 45 – 60 mins weekly sessions One year follow-up	Behaviour Modification Social Support Nutrition Education Exercise Instruction <u>3 Groups:</u> Group 1 - Mother-child separately Group 2 - Mother-child together Group 3 - Child alone	<u>Body Weight & BMI</u> Group 1- ↓8.4 ± 1.3kg BMI - ↓4.7 ± 0.6 Group 2- ↓5.3 ± 1.6kg BMI - ↓3.0 ± 0.9 Group 3- ↓6.8 ± 2.0kg BMI - ↓2.0 ± 0.6 <u>1 year follow-up</u> Group 1- ↓7.7 ± 4.1kg BMI - ↓4.6 ± 1.9 Group 2- ↑2.9 ± 2.1kg BMI - ↓0.1 ± 0.9 Group 3- ↑3.2 ± 1.7kg BMI - ↓0.1 ± 1.0
Carrel et al. (2005)	9 months School based	Intervention Group - 42 mins of lifestyle focused physical exercise; max 14 students per class Control Group - 25 mins of traditional physical education class; max 40 students per class Frequency - 5 times every 2 weeks Small nutritional component for both groups	<u>Average Weight Change</u> <u>Intervention Group</u> ↓4.1% ± 3.4% BF <u>Control Group</u> ↓1.9% ± 2.3% BF
Christakis et al. (1966)	18 months School & home based	Nutrition Education - Biweekly approx. 30-45 mins Physical Education programme	<u>Decrease in average overweight</u> <u>Intervention Group</u> - ↓11% <u>Control Group</u> - ↓2%
Gately, P.J. and Cooke, C.B. (2003)	4 weeks Residential Fee paying	Physical Activity - six 1 hour sessions per day Behaviour Modification - 3 x a week Dietary Restriction - individual metabolic rate (WHO 1997)	<u>Average Weight Change</u> Body Weight - ↓5.6kg BMI - ↓2.1 Body Fat - ↓3%

Abbreviations: BF – Body Fat, BMI - Body Mass Index (kg/m²).

Table 5. Continued

Author and Year	Programme	Intervention	Results
Gately et al. (2000)	8 weeks Residential summer camp Fee paying	Dietary Restriction – 5860kj/day Daily physical activities Behavioural/educational sessions	<u>Average Weight Change</u> Body Mass - ↓13% BMI - ↓12% BF - ↓14% 10 month follow-up (see below)
Gately et al. (2000)	8 Weeks Residential summer camp Fee paying	Dietary Restriction – 5860kj/day Daily physical activities Behavioural/educational sessions	<u>Average Weight Change</u> Body Mass - ↓11.2kg BMI - ↓4.4 <u>10 Month Follow-up</u> 10% continued to ↓body mass, 26% continued to ↓BMI <u>1 Year</u> 91% ↓BMI compared to week 0.
Gately et al. (2005)	2-6 Weeks Residential summer camp Fee paying	Six 1-hour physical activity sessions a day. Moderate dietary restriction – using equations from Schofield (1985) 4 educational sessions per week	<u>Average Weight Change</u> ↓6kg ↓BMI by 2.4 units ↓BMI SD Score 0.28
Gortmaker et al. (1999)	2 School years School based	Decreasing television viewing Increasing physical activity Decreasing high-fat foods Increasing fruit & vegetable intake	<u>Obesity in Females</u> Control - ↑2.2% Intervention - ↓3.3% <u>Males -</u> No significant difference
Gutin et al. (2002)	8 Months Institute based	Group 1 - Lifestyle education (LSE) classes Group 2 - LSE & moderate-intensity physical training Group 3 - LSE & high-intensity physical training	<u>Average Weight Change in % of BF</u> Group 1 - ↓0.19 ± 0.62 Group 2 & 3 combined - ↓3.57 ± 0.80 ²
Seltzer, C.C. and Mayer J. (1970)	5 Months School based	45 min physical activity classes, 5 times a week; max 15 per class Nutritional information Psychological support throughout	No. of students showing a decrease: <u>Triceps Skinfold</u> Intervention - 46.6% Control - 32.9% <u>Body Weight</u> Intervention - 23.3% Control - 8.7%
Zakus et al. (1981)	9 Weeks School based	Nutrition education Aerobic Exercise and Conditioning Behaviour modification principles	<u>Average Weight Change</u> <u>Intervention Group</u> ↓1.80 lbs <u>Comparison Group</u> ↑ 4.75 lbs 8 month follow-up: Intervention - ↓9.26% Comparison - ↓0.86%

Abbreviations: BF – Body Fat, BMI - Body Mass Index (kg/m²).

Triceps skinfold measurements

Variations in triceps skinfold cut-off measures existed between studies (Table 4); dependant on which research recommendations were adopted. Sardinha et al. (1999) stated that triceps skinfold measurement correlated well with total adiposity; standard error associated with skinfolds is less than 3.5%, compared to a 2.7% error for hydrostatic weighing (ACE 1997). However, limitations exist:

- Intra-abdominal fat accumulation is not assessed (ACE 1997).
- Measurements are taken from the triceps and then a calculated 'assumption' is made of total body fat on that one measurement (ACE 1997).
- Callipers can be uncomfortable for the adolescent
- The type of callipers used can affect the accuracy of readings. Jackson and Pollock (1985) stated that inexpensive plastic callipers produced higher readings, although a comparison was only made against one type of calliper (Lange callipers).
- Precise measurements need to be taken during follow-up (human error).

Intervention Methods

Main intervention methods used were dietary intervention, physical activity and behaviour modification (Table 5). Each study varied in their method applied.

Dietary Interventions

All four residential based studies used dietary restriction (Table 5), although only two studies based this on individual children's metabolic rates, this is recommended by the World Health Organisation (1997). Both studies varied in the equations used (Table 5). Each adolescent is unique in their daily energy requirements, depending on size, age, sex and basal metabolic rate (Gately et al. 2000). Dietary restriction within this age group, especially in long duration intervention studies, needs to consider growth and development (Seltzer and Mayer 1970). Wardle (1996) also highlighted that adherence to diets is low and may even instigate weight gain in the long term. Residential

control over diets is limited in establishing lifestyle changes within a family, due to a lack of 'teaching' adolescents and parents how to manage their own diet and calculate calorific intake; difficulties in replication in the normal lifestyle setting also exist. The dietary intervention of the other eight studies was in the form of class meetings, with nutritional handouts and food diaries (Table 5).

The majority of the studies were lacking in sufficient detail to enable replication of the intervention, making validity of results difficult. Other limitations to the dietary intervention of the studies exist:

- Food Diaries rely on honesty and recall methods in reporting correct amounts and food types (Stanton 2006). Although a study by Bingham et al. (1994) found that an unstructured 7-day diary was unbiased in mean intakes of food and nutrients.
- Adolescents may 'adjust' their diets to simplify recording of data (Stanton 2006).
- Studies were short-term; not long enough to establish lifestyle changes, making it difficult to reflect on long-term success of dietary interventions.
- Adolescents may have difficulty in managing their own diet if parents are purchasing and providing meals.
- Only two of the twelve studies included parents in the dietary education process. Golan and Crow (2004) found that in a seven year follow-up programme, mean reduction in children's weight was greater when parents were involved.
- Gutin et al. (2002), Becque et al. (1988) and Brownell et al., (1983) used rewards for compliance to the nutritional intervention; this may cause bias due to increased motivation and cannot be generalised to the population.
- Obese adults under-report their kilojoules intake by 39% (Weber et al. 2001).

Physical Activity

Physical activity interventions varied between studies (Table 5). Only one study, Gutin et al. (2002) prescribed individual exercise programmes tailored

to the adolescent's initial test results; although this study used a generic energy expenditure of 250 Kcal per session, the duration of the exercise session was then adjusted accordingly. This will have limited potential weight loss in some subjects.

Two studies (Seltzer and Mayer 1970 and Christakis et al. 1966) were completed before 1980 (Table 5); the physical activity component in these studies would not be recommended today, due to advances in exercise science and injury prevention. Controversy between studies exists in relation to competitive sports, with some studies emphasising competitiveness and others avoiding it. 50% of the studies concentrated on developing physical activity skills; research has found a connection between sporting participation during childhood and adult physical activity levels (Sports Council and Health Education Authority 1992). A wide choice of activities that appeal to both sexes is recommended (American College of Sports Medicine (ACSM) (1998); more research in to this area in relation to obese adolescents is needed. However it is universally accepted that physical activity should be fun. Two studies (Brownell et al. 1983 and Zakus et al. 1981) (Table 5) were very vague on the physical activity component, making replication difficult.

Only two studies (Becque et al. 1988 and Gutin et al. 2002) monitored the exercise intensity level, using heart rate monitors. Heart rate monitoring is the preferred method for monitoring physical activity in children and adolescents (Livingstone et al. 1992). Although, the ACE (1997), stated that the use of a perceived exertion scale (Appendix 1) to monitor children's intensity levels, is more appropriate and has been showed to be significantly accurate. Becque et al. (1988) used the adult formula $220 - \text{age}$ to predicted maximum heart rate and calculate required percentage of exercise heart rate. Up until maturity heart rate maximum is between 195 – 215 beats/min in children (ACSM 1998). The optimum intensity for aerobic exercise is at the upper end of recommendations for adults (Sady 1986).

There is no established exercise guidelines on adolescent weight loss, due to the variability of interventions, environments and methods used. Most of the intervention methods were lacking in sufficient detail to enable replication and the age of the study impacted on the type of physical activity initiated. Intensity of activity was estimated in most of the studies. No current guidelines on the recommended levels of aerobic, muscular endurance or flexibility training exist for children/adolescents (Armstrong and Welsman 2000). However, enough data exists to confirm that adolescents cannot be considered as 'mini-adults' (Armstrong and Welsman 2000).

Table 6. Attrition Rates

Author and Year	No. Subjects	Attrition	
Becque et al. (1988)	36	Not stated	
Brownell, Kelman, and Stunkard (1983)	42	16 weeks 38 10%	1 year 36 14%
Carrel et al. (2005)	50	3 (6%) - control group. Data was not included in the analysis	
Christakis et al. (1966)	90	6 (7%) – intervention group 2 (2%) - control group. Total attrition – 9% Data was not included in the analysis	
Gately and Cooke (2003)	39	1 (2.5%) – intervention group Data was not included in the analysis	
Gately et al. (2000)	194	Not stated	
Gately et al. (2000)	102	53% of subjects returned to camp 1 year later. Attrition rate from this not stated	
Gately et al. (2005)	279	17 (6%) – intervention group Data was not included in the analysis	
Gortmaker et al. (1999)	1560	35.2% - intervention group 35.5% - control group	
Gutin et al. (2002)	80		
Seltzer and Mayer (1970)	350	Not Stated	
Zakus et al. (1981)	22	5 (14%) – intervention group 8 (23%) – control group	

Success of Interventions

All twelve studies stated their interventions as successful in reducing weight, body fat or BMI. Results comparison between studies is difficult due to the differing measurements in assessing changes in body mass, inconsistent cut-off points in defining overweight/obesity and variations of statistical analysis. As the studies were multi-component and heterogeneous in their intervention methods, it is difficult to analyse which combination of interventions provided the best results. However, two studies (Gutin et al. 2002 and Becque et al. 1988) (Table 5) found a greater reduction in body fat percentage and weight (respectively), using an intervention combination of nutrition, lifestyle change and physical activity, than nutrition and lifestyle change alone.

The two year school based study (Gortmarker et al. 1999) showed a significant obesity decrease in girls, but no significant decline in boys compared to the control group (Table 5).

Studies involving Parents

Brownell et al. (1983) found that after sixteen weeks adolescents lost a greater amount of weight when mother and adolescent attended the interventions separately, than when mother and adolescent attended together, or the adolescent attended alone; these results were also reflected after a one year follow-up period (figure 2).

Seltzer and Mayer (1970) included parents in the nutritional aspect of their study intervention; results showed a greater decrease in percentage of body weight than the control group. However, the success of including parents or not was not measured in this study.

Follow-Up

Gately et al. (2000) found that 10% of subjects continued to reduce their body mass during a 10 month follow-up (Table 5). A comparison using percentile data was made to account for growth and maturation during the 10-month

period. However, no control group was used, making a reliable assessment of growth and maturation difficult.

Zakus et al. (1981) highlighted that weight loss increased in the 8-month follow-up period and were significantly higher than the control group. However, a very small sample size was used for this study.

Reward for Compliance

Gutin et al. (2002), Becque et al. (1988) and Brownell et al. (1983) (Tables 4 & 5) used rewards for compliance and attendance on the course. This may affect the generalisation of study results due to subjects or parents being motivated by monetary incentives.

Discussion

Universal cut-off markers for overweight and obesity need to be established, as well as standard guidelines between studies to identify growth and maturation changes in adolescents. Due to the lack of undefined theoretical frameworks between studies, small sample sizes and short duration interventions, no 'standard' weight loss guidelines are apparent. Most of the studies rely on self-reporting and recall when monitoring dietary changes and physical activity; however concerns exist between the accuracy of self-reporting (Baranowski et al. 1992). A more structured exercise programme maintaining a fun element and monitoring intensity levels using both heart rate monitoring and Borg's Rate of Perceived Exertion is needed.

Dietary restriction has been shown to decrease body mass on a short-term basis, however long term adherence to diets is low. Nutritional interventions are vague and the monitoring of dietary intake can pose limitations. It is clear that long term adherence to physical activity and dietary changes is left virtually unmeasured; rendering most of the study interventions as unreliable in finding long term solutions. The distinct lack of longitudinal studies on obese adolescents is due to difficulties in differentiating what is 'normal growth', dietary restriction within the growing child may be unethical and lack of

programme adherence may limit experimental procedures. Long term success of weight loss interventions is vital in preventing adult obesity; therefore long term study analysis is required to give reliability to the strategies used.

Residential summer camps and school based programmes accounted for 75% of the studies reviewed: indicating the need for further community based research. Normal physical activity curriculum classes were continued for both intervention and control groups, however the amount, frequency and intensity of these classes was not stated. National curriculum physical activity has changed considerably over the last decade, which may reflect on the interpretation of results in older studies. Evidence points to Increasing the frequency of practical physical exercise sessions in schools.

A residential based and school based study showed continuing success on follow-up, however weight loss percentage was small and conflicting research within differing age ranges exist; a review by Fowler-Brown and Kahwati (2004) found that multi-component school based intervention programmes were not effective in reducing overweight in adolescents. Residential summer camps, although available mainly to socially privileged individuals, may be a 'kick-start' in motivating adolescents, offering the opportunity to try different sports and develop skills, however the long term success of these programmes is questionable.

Involving parents in lifestyle changes has shown to initiate greater long term results, although the evidence in this field is not conclusive. However, most behavioural change has an increased chance of success with a background of social support (Irwin and Morrow 2005). Gortmarker et al. (1999) highlighted that girls may be more responsive to weight loss interventions than boys, due to an increased awareness of diet and activity issues; none of the other studies supported this theory. Other studies have shown participation levels of physical activity to be higher in boys than girls (Armstrong 1989).

The opportunity to control obesity in adulthood lies in tackling the problem in the pre-adult stage; emphasising the need for long-term success control measures (Selzer and Mayer 1970). Current predictions are that by the year 2010, a third of men and more than a quarter of women will be obese (NAO 2001). Investments in longitudinal research needs to be made and due to the time span needed to track successful interventions through childhood to adulthood, unless these studies are put in place soon, the obesity epidemic will continue to escalate.

The Government is currently working towards increasing awareness of the situation and initiatives specifically targeting schools are being put in to place (Summerbell et al. 2002). The current eating habits, beliefs and understanding of obesity problems in adolescents and their families needs to be assessed, in order to help motivate and educate adolescents to make positive lifestyle changes.